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ORIGINAL ARTICLE

Prevalence of chronic obstructive pulmonary disease in Korea: The fourth Korean National Health and Nutrition Examination Survey, 2008

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ABSTRACT

Background and objective: **Because the mortality and social burden associated with COPD is increasing, repeated surveys of the prevalence of COPD have been used to assess risk factors, detect potential patients, and establish early diagnoses and management protocols. We report the prevalence of spirometrically detected COPD in Korea in 2008, using data from the fourth Korean National Health and Nutrition Survey.**

Methods: **Using nationwide stratified random sampling, based on the Korean Statistical Office census, 6840 subjects aged ≥19 years underwent spirometry, which was performed by four trained technicians, during 2008. The place of residence, levels of education and income and smoking status, as well as other results from a COPD survey questionnaire were also assessed.**

Results: **Airflow obstruction ($FEV_1/FVC < 0.7$) was detected in 8.8% of subjects aged ≥19 years (11.6% of men and 5.9% of women) and COPD was detected in 13.4% of subjects aged ≥40 years (19.4% of men and 7.9% of women). Of the 6840 subjects, 27.3% were current smokers and 17.2% were former smokers, and the prevalence of COPD was higher in current and former smokers than in never smokers. Approximately 94% of patients with COPD had mild-to-moderate disease, without apparent symptoms; only 2.4% had been diagnosed by a physician and only 2.1% of patients had been treated. The independent risk factors for COPD were smoking, advanced age and male gender.**

Conclusions: **Although the prevalence of COPD in Korea is high, the disease is underdiagnosed and most COPD patients are under-treated.**

SUMMARY AT A GLANCE

A nationwide survey of a Korean population, with stratified random sampling, revealed that the prevalence of COPD was high (13.4%) but that most COPD patients were undiagnosed or under-treated. This study provides further evidence that COPD is prevalent but is underdiagnosed and undertreated.

Key words: chronic obstructive pulmonary disease, Korea, prevalence, spirometry, survey.

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INTRODUCTION

COPD is a major disease that is increasing in prevalence and mortality, worldwide.[1–5] In Korea, it has been estimated that mortality from COPD will increase by 30% within 10 years.[6] The total hospitalization expenses associated with COPD increased from 111 billion Korean won (USD 110 million) in 2004 to 170 billion won (USD 170 million) in 2007.[7] In addition, COPD ranked 10th among the causes of death in Korea in 1999 (mortality rate, 13.7 per 100 000 population), and rose to 7th in 2008 (mortality rate, 14.8 per 100 000 population).[6] Therefore, the burden on national health services due to COPD is great, and nationwide attention is needed to prevent COPD and reduce its burden on society.

The worldwide prevalence of COPD has been estimated at 7.5–10%. The prevalence as assessed by pulmonary function tests (PFT) is higher than that assessed from patient reports using questionnaires (9.2% vs 4.9%).[8] This discrepancy may be due to the asymptomatic nature of the disease in many subjects, resulting in underdiagnosis by physicians[9] and lack of awareness of COPD as a disease entity.[10] Therefore, PFT are necessary to accurately estimate the prevalence of COPD.

Regular spirometric surveys of the population have enabled the identification of patients with mild COPD and no or minimal respiratory symptoms, as well as patients with moderate-to-severe COPD, who have never been diagnosed by physicians. In addition, spirometric surveys can be used to determine the risk factors for COPD and clinical outcomes in patients with this disease. Spirometric results from the second Korean National Health and Nutrition Survey (KNHANES II) indicated that in 2001, the prevalence of COPD in Korean subjects aged ≥45 years was 17.2% (men, 25.8%; women, 9.6%).[11] Further surveys on the prevalence of COPD and follow up of these subjects were not performed until 2007, and the criteria for the standardization of PFT were revised in 2005.[12] The Korean Academy of Tuberculosis and Respiratory Diseases and the Korea Center for Disease Control and Prevention conducted a survey on national health and nutrition, including assessment of COPD prevalence, beginning in 2007. Here we report on the prevalence of COPD in Korea in 2008, using data from the fourth Korean National Health and Nutrition Survey (KNHANES IV).

METHODS

Study design

During 2008, the second year of KNHANES IV, nationwide stratified random sampling was performed based on data from the Korean Statistical Office census. The 500 survey areas were drawn from a census of population and housing by considering the proportion of each subgroup. Spirometry was performed, and a trained interviewer administered a questionnaire on respiratory diseases and various health-related information, including place of residence, education, income and smoking status. For spirometric testing, 6840 subjects aged ≥19 years from the Korean population were selected. Of these 6840 subjects, 4523 were aged ≥40 years, and the prevalence of COPD in this age group was evaluated.

The study was approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention (approval number, 2008-01EXP-01-C) and informed consent was obtained from all study participants.

Sampling strategy in the KNHANES IV

For the KNHANES IV, 23 households were sampled per clustering unit, which consisted of 60~80 households. Survey clusters were selected in each stratum, into which the population was divided according to residential area (rural, urban), type of housing (apartment house, non-apartment house) and population gender and age structure (child, adult and elderly by gender). Twenty-three households within a cluster were selected using a systematic sampling method. The sample was weighted to adjust for over-sampling, non-responders and post-stratification.

Spirometry

Spirometry was performed by four technicians, each of whom underwent two education sessions on PFT and quality control. Spirometry was performed using dry rolling seal spirometers (Model 2130; SensorMedics, Yorba Linda, CA, USA) and the American Thoracic Society/European Respiratory Society criteria for the standardization of PFT.[12] Spirometric prediction equations were derived from survey data on nonsmokers with normal CXR findings and no history of respiratory disease or symptoms.[10]

Spirometric data obtained on site by technicians were transferred to the review centre on the internet. Another trained technician assessed whether or not the data met the criteria for acceptability and reproducibility, and provided quality control feedback to the technicians, which improved the performance of spirometry. Data were finally confirmed by the principal investigator and saved in the data management system of the Korea Center for Disease Control and Prevention.

Questionnaire for COPD survey

Trained interviewers administered the questionnaire at the time of PFT, to determine whether (i) the subject had a history of COPD, such as chronic bronchitis or emphysema; (ii) had been diagnosed with COPD by a physician; and (iii) had been treated for COPD.

Criteria for the assessment of COPD

An $FEV_1/FVC < 70\%$ was defined as airflow obstruction in subjects aged 19–39 years, and as COPD in

subjects aged ≥40 years. The severity of COPD was categorized according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria, using data from pre-bronchodilator tests.[13] Analyses were performed only on data that met the following criteria: (i) ≥2 acceptable spirometry curves showing correct starting of the test and expiration for at least 6 s; and (ii) a greatest difference between two measurements of FEV_1 or FVC of <150 mL.

Definitions for smoking status, place of residence and income

Definition of current, former and never smokers

A never smoker was defined as someone who had smoked fewer than 100 cigarettes during their lifetime. A smoker was defined as someone who had smoked ≥100 cigarettes. Among the latter group, those who answered in the affirmative to the question 'Do you currently smoke?' were defined as current smokers, whereas those who answered in the negative were defined as former smokers.

Definition of place of residence

In South Korea, the smallest administrative districts are Dong, Eup and Myeon. Eup and Myeon are the smallest districts in a rural area, and Dong is the smallest district in a city. If a subject's address was located in a Eup or Myeon, the place of residence was defined as rural, whereas if the address was in a Dong, the place of residence was defined as urban.

Definition of income

Income was categorized by ranking according to gender and age group in 5-year intervals. Each subject's income was calculated by dividing the total household income by the square root of the number of members in the household.[14]

Statistical analyses

To estimate representative national health status, we adjusted for the complex sample design. To adjust for unequal probabilities of selection, all estimates were calculated based on sampling weights for sample area, household selection rate, and sample household and response rate of the subjects. These weighted values were adjusted for gender and age using post-hoc analysis, to produce results that were representative of the entire Korean population.

Sample design and sampling weights were determined using the SURVEY PROCEDURE in SAS 9.1.3 (SAS Institute Inc., Cary, NC, USA). The prevalence of COPD was determined using the SURVEYFREQ procedure (SAS Institute Inc.). Comparisons between performance and non-performance of spirometry, and between satisfactory and unsatisfactory acceptability and reproducibility of spirometry were tested using the chi-square test. Data were expressed as means ± SEM.

RESULTS

A total of 6840 subjects aged ≥19 years (mean age, 49.0 ± 0.5 years) were identified. Of these, 4523 (41.7% male; 58.3% female) were aged ≥40 years (mean age, 58.4 ± 0.3 years; men, 57.6 ± 0.3 years; women, 58.9 ± 0.4 years). Of these 4523 subjects, 99.6% completed the questionnaire and 92.1% (4166) underwent spirometry, whereas 7.9% refused spirometry. Of the 4166 subjects who performed spirometry, acceptability and reproducibility criteria were satisfied for 2501 (60.0%) (Fig. 1). The proportion of PFT results that satisfied the criteria for acceptability and reproducibility decreased significantly with age ($P < 0.001$), but was not related to gender, residential area or income.

Overall prevalence and severity of COPD

Of the subjects aged ≥19 years who satisfied the criteria for acceptability and reproducibility of spirometry, 8.8% (SEM 0.6) had airflow obstruction (11.6% (0.9) of men and 5.9% (0.6) of women). Of the 2501 subjects aged ≥40 years who satisfied the criteria for acceptability and reproducibility of spirometry, 13.4% (0.9) had COPD (19.4% (1.5) of men and 7.9% (0.1) of women) (Table 1). The prevalence of COPD was significantly higher in men than in women and increased with age (Fig. 2). Of the subjects diagnosed with COPD, the severity of disease was GOLD stage I or II in 94% (Fig. 3).

Risk factors for COPD

Of the 2501 subjects aged ≥40 years, 22.9% (41.8% men) were current smokers and 21.3% (41.2% men) were former smokers (Table 2). The overall prevalence of COPD was significantly higher in former and current smokers than in never smokers (Table 3). Multivariate analysis showed that age ≥65 years, male gender, low income and smoking status were significant independent risk factors for COPD (Table 3).

Awareness of COPD

Of the 354 subjects who were confirmed as having COPD, 353 completed the questionnaire. Of these subjects, nine (2.4%) reported having been diagnosed with COPD by a physician and eight (2.1%) reported having been treated.

DISCUSSION

In the KNHANES IV, the prevalence of COPD was 13.4% among subjects aged ≥40 years (19.4% of men,

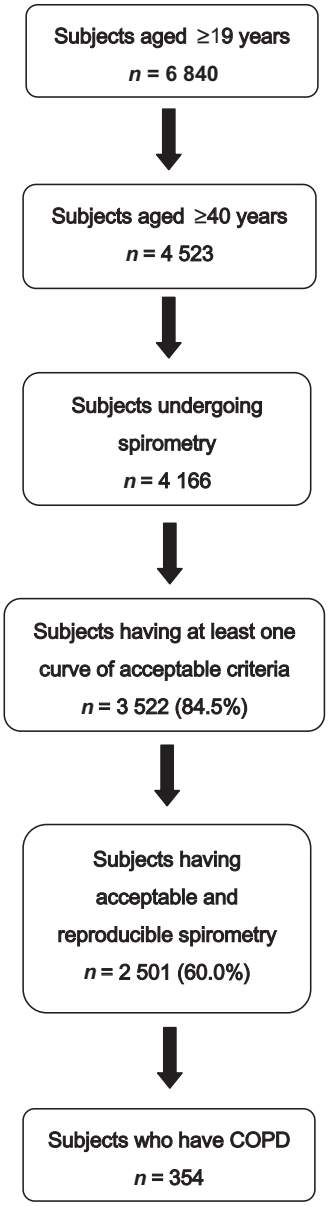

Figure 1 Selection of subjects for analysis of the prevalence of COPD. The numbers of subjects as percentages of those who underwent spirometry are indicated in parentheses.

7.9% of women). The overall worldwide prevalence of COPD has been reported to be 7.5–10%,[8] suggesting that the prevalence of COPD is higher in Korea. The prevalence of COPD in the KNHANES II, performed in 2001, was 17.2%.[11] The discrepancy in the prevalence of COPD between KNHANES II and IV may be attributed to differences in the reproducibility criteria for quality control of PFT rather than to an actual decrease in the prevalence of COPD.

In KNHANES II, data from subjects with at least two acceptable spirometry curves were analysed, whereas in KNHANES IV, data were only analysed if there were at least two acceptable spirometry curves and the data were also reproducible (largest and second largest FEV_1 and FVC determinations within 150 mL of each other). In KNHANES IV, 75.2% of the subjects who performed spirometry had at least two acceptable spirometry curves (the criterion in KNHANES II) and 60.0% had at least two acceptable spirometry curves with reproducible data (the criteria in KNHANES IV). The frequency of unsatisfactory spirometry curves increased with age ($P < 0.001$). Elderly subjects, among whom there would be a high prevalence of COPD, were underrepresented in the KNHANES IV analysis, which may have resulted in the reporting of a lower overall prevalence of COPD in KNHANES IV compared with KNHANES II. When re-calculated by applying the same criteria used in KNHANES II (subjects aged ≥45 years with at least two acceptable spirometry curves without any reproducibility criteria), the prevalence of COPD in the present population was 17.7% (28.2% in men; 9.3% in women), which was similar to the prevalence reported in KNHANES II (17.2%).

The annual decline in FEV_1 has been shown to be greater in COPD patients than in healthy subjects.[15,16] As the severity of COPD increases, so does the frequency of hospitalization and the mortality rate, which in turn results in an increase in medical expenses. COPD patients with severe pulmonary dysfunction have a 9.5-fold higher rate of hospitalization[17] and a 2.7-fold higher rate of mortality than subjects without COPD.[18] Therefore, a reduction in the annual decline in FEV_1 is of crucial importance in the treatment of COPD. However, there are no effective treatments that reduce the annual decline in FEV_1, although several large prospective studies have reported that early treatment of patients with mild-to-moderate COPD can reduce mortality and the annual decline in FEV_1.[19–21] Therefore, it is important to identify patients with early-stage COPD (mild or no symptoms) and to provide them with appropriate treatment.

Of the subjects diagnosed with COPD, 94% had mild-to-moderate COPD (early-stage COPD) according to the GOLD criteria, which was similar to the result from KNHANES II (95%). Patients with mild-to-moderate COPD usually do not visit a clinic, due to the absence of clinical symptoms such as cough and dyspnoea, and they are therefore often not diagnosed with COPD.[8] Even subjects who have been diagnosed, however, do not receive adequate long-term treatment.[22,23] Indeed, the present data showed that only 2.1% of the subjects diagnosed with COPD received treatment.

Smoking is the most common cause of COPD. Among the subjects surveyed in KNHANES II, who were aged ≥45 years, 27.5% were current smokers and 12.7% were former smokers. In comparison, among subjects aged ≥45 years surveyed in KNHANES IV, 21.4% (38.9% male) were current smokers and 22.3% (43.7% male) were former smokers. In smokers, the annual decline in FEV_1 is more rapid,[15] whereas early smoking cessation may slow the annual rate of decline in FEV_1.[24–26] Based on these results, smoking cessation should be the first step in preventing the development of COPD.

Table 1 Prevalence of airflow obstruction stratified by place of residence, education and income

	Total population		Men		Women	
	Number of subjects	Prevalence %	Number of subjects	Prevalence %	Number of subjects	Prevalence %
Age						
≥19 years	3435	8.8	1478	11.6	1957	5.9
≥40 years	2501	13.4	1056	19.4	1445	7.9
Place of residence						
Rural	1741	12.2	730	17.4	1011	7.5
Urban	760	17.8	326	25.9	434	9.5
Education						
Elementary school or lower	957	21.2	275	38.6	682	12.7
Middle school	423	15.1	201	22.7	222	6.4
High school	712	7.0	318	11.4	394	2.6
College or higher	401	8.5	256	10.2	145	5.3
Income						
Low	561	14.6	221	20.6	340	9.2
Low ~ middle	596	13.2	257	19.7	339	7.0
Middle ~ high	629	11.8	281	17.7	348	5.8
High	642	10.7	267	15.6	375	6.6

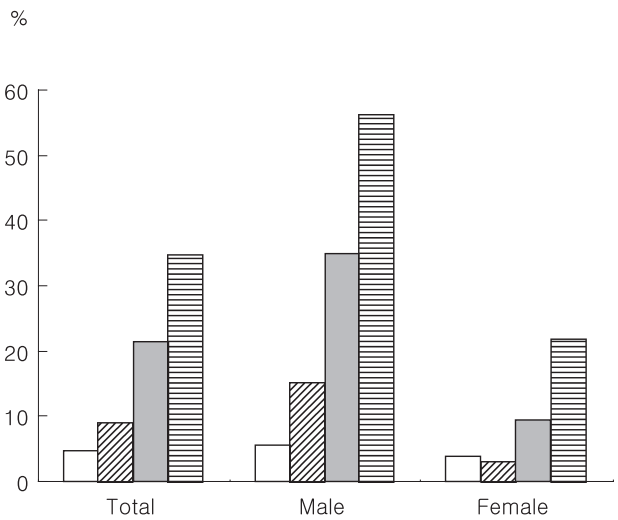

Figure 2 Prevalence of airflow obstruction stratified according to age groups. (□) 40–49 years; (▨) 50–59 years; (■) 60–69 years; (▤) ≥70 years.

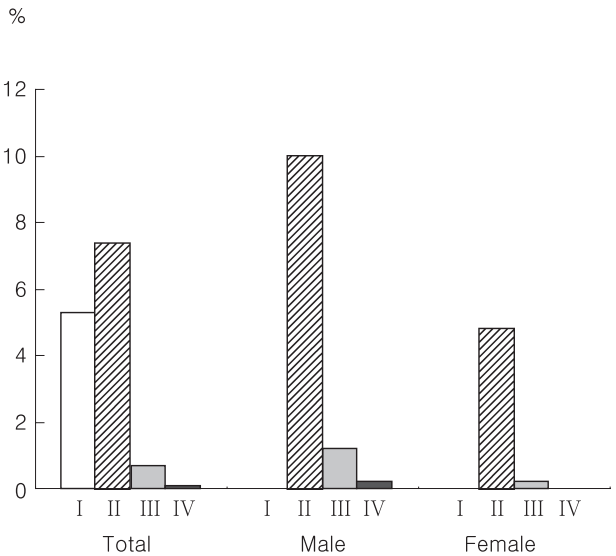

Figure 3 Prevalence of airflow obstruction among subjects older than 40 years, stratified according to GOLD classification. I, II, III and IV indicate the GOLD stages of increasing severity of COPD. GOLD, Global Initiative for Chronic Obstructive Lung Disease.

Estimates of the prevalence of COPD are usually lower when based on questionnaire surveys only, compared with those that use PFT. A meta-analysis of 62 studies from 28 countries reported that the prevalence of COPD was 9.2% in surveys that used PFT, but only 4.9% in surveys that used questionnaires alone.[8] Estimation of the prevalence of COPD by questionnaires may be confounded by various factors.[9] Because the prevalence of COPD is about twice as high in surveys using PFT compared with those using questionnaires, surveys of the prevalence of COPD should include PFT.

With regard to all characteristics except age, subjects who satisfied the requirements for acceptability and reproducibility of spirometry did not differ significantly from those who did not satisfy the requirements. The age distribution of the subjects who satisfied the requirements was similar to that of all subjects who underwent spirometry. Therefore, the subjects who satisfied the requirements can be considered to be representative of the total population.

This survey had several strengths, including the use of a perennial survey system, thus minimizing seasonal and regional variations. Second, the values obtained from the survey were representative of those

Table 2 Percentage of smokers stratified by age and gender

Smoking status	Total population (%)		Men (%)		Women (%)	
	>19 years	>40 years	>19 years	>40 years	>19 years	>40 years
Current	27.3	22.9	47.7	41.8	7.3	5.5
Former	17.2	21.3	30.5	41.2	4.2	3.0
Never	55.5	55.7	21.8	17.0	88.5	91.5

Table 3 Univariate and multiple logistic regression analyses assessing the risk factors for COPD

	n	%	Univariate analysis			Multivariate analysis		
			OR	*P*-value	95% CI	OR	*P*-value	95% CI
Age, years								
<65	1812	8.0	Reference	—	—	Reference	—	—
≥65	689	31.1	1.45	>0.05	0.88–2.37	1.78	<0.05	1.01–3.17
Gender								
Female	1445	7.9	Reference	—	—	Reference	—	—
Male	1056	19.4	4.01	<0.001	2.84–5.68	3.07	<0.001	1.90–4.97
Place of residence								
Rural	1741	12.2	Reference	—	—	Reference	—	—
Urban	760	17.8	1.30	>0.05	0.95–1.77	1.18	>0.05	0.85–1.63
Education								
Elementary	957	21.2	Reference	—	—	Reference	—	—
College or higher	401	8.5	0.96	>0.05	0.52–1.76	0.60	>0.05	0.30–1.20
Income								
Low	561	14.6	Reference	—	—	Reference	—	—
Low ~ middle	596	13.2	0.85	>0.05	0.57–1.28	0.89	>0.05	0.58–1.38
Middle ~ high	629	11.8	0.73	>0.05	0.47–1.13	0.86	>0.05	0.54–1.36
High	642	10.7	0.61	<0.05	0.39–0.96	0.87	>0.05	0.54–1.39
Smoking								
Never	1506	7.7	Reference	—	—	Reference	—	—
Former	501	17.7	2.48	<0.001	1.66–3.64	1.28	>0.05	0.77–2.11
Current	485	22.9	5.41	<0.001	3.64–8.05	2.80	<0.001	1.76–4.45

for the Korean population, following post-hoc analysis according to age and gender. Third, technical and personal errors were minimized by the use of criteria for both acceptability and reproducibility of spirometry.

This survey also had several limitations. First, CXR were not obtained for the study participants. As diseases other than COPD, such as bronchiectasis and pulmonary tuberculosis, may cause airflow obstruction, the true prevalence of COPD may have been lower. However, KNHANES II indicated that there was no significant difference in the prevalence of COPD between subjects who did or did not undergo CXR. Second, a fixed FEV_1/FVC ratio was used to define airflow obstruction, without consideration of the decrease in pulmonary function with age. Thus, the data that were analysed were obtained from pre-bronchodilator PFT, while the prevalence of COPD in elderly subjects appeared to be overestimated.[27,28] Third, pre-bronchodilator testing was used for the diagnosis of COPD,[13] which may have resulted in the inclusion of asthmatic patients and overestimation of the prevalence of COPD.[29,30] Therefore, to accurately determine the prevalence of COPD, post-bronchodilator PFT results should be used. However, recommended testing procedures differ in the US NHANES (2008),[31] GOLD,[13] and American Thoracic Society/European Respiratory Society guidelines.[12] Fourth, the proportion of subjects with acceptable and reproducible spirometry was rather low (60%). Therefore, the characteristics of subjects who did or did not satisfy the criteria for acceptability and reproducibility were compared and no differences were found, except for age.

In this survey, the prevalence of COPD in subjects aged >40 years was 13.4%, with >90% having mild disease. A considerable number of subjects had not been diagnosed with COPD, and many subjects who were diagnosed with COPD did not receive appropriate treatment. By the use of spirometry, patients with mild, as well as moderate-to-severe COPD, who had not been diagnosed, were identified. These surveys should be continued to determine and reduce risk factors until the prevalence and social burden of COPD has decreased sufficiently. A fifth survey (KNHANES V) is presently being conducted, using new criteria for spirometric testing that require at

least three acceptable curves, as well as reproducibility. By including the use of bronchodilator(s) and defining airflow obstruction relative to the lower limits of normal, KNHANES V is expected to provide a more accurate estimate of the prevalence of COPD in Korea.

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